Exploring Hyperons and Hypernuclei with Lattice QCD

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In this work we outline a program for lattice QCD that would provide a first step toward understanding the strong and weak interactions of strange baryons. The focus on strange baryons is motivated by two reasons. First, Λ-nucleon interactions are less sensitive to the pion mass and, consequently, have the promise to be measured on the lattice before nucleon-nucleon interactions are, as realistic values of the pion mass represent an outstanding challenge to lattice technology. Second, very little is known about Λ-nucleon interactions that can be of use in modeling hypernuclei, a field where considerable experimental effort is being invested.

The study of hypernuclear physics has provided a significant amount of information regarding the structure and weak decays of light nuclei containing one or two Λ's, and Σ's. From a theoretical standpoint, little is known about the hyperon-nucleon interaction, which is required input for systematic calculations of hypernuclear structure. Furthermore, the long-standing discrepancies in the P-wave amplitudes for nonleptonic hyperon decays remain to be understood, and their resolution is central to a better understanding of the weak decays of hypernuclei. Thus, the weak decays of strange baryons and their interaction with nucleons are closely related. We present a framework that utilizes Luscher's finite-volume techniques in lattice QCD to extract the scattering length and effective range for Lambda-N scattering in both QCD and partially-quenched QCD. The effective theory describing the nonleptonic decays of hyperons using isospin symmetry alone, appropriate for lattice calculations, is constructed. In particular we present formulae that allows for the extrapolation on the quark masses towards the realistic values.

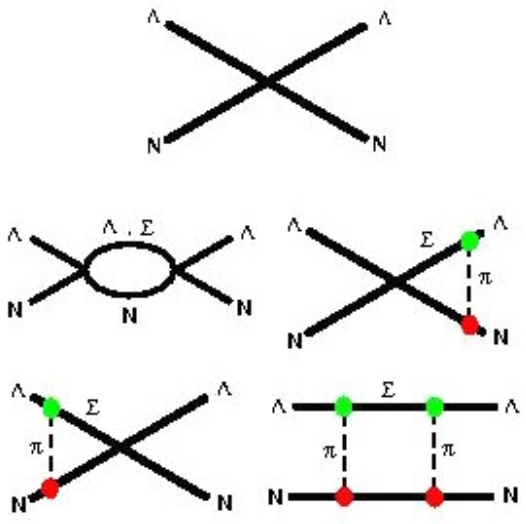

FIG. 1: Graphs contributing at leading and next-to-leading order to Λ-N scattering.

REFERENCES

[1] S. R. Beane et at., *nucl-th/0311027* .